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ABSTRACT

In order to obtain principals' and teachers' ideas about the Kansas Science Education Standards, this study sought to determine the perspectives of Kansas' principals and teachers as they related to the implementation of these standards. Given this purpose, the expectation was that principals and teachers would have differing perspectives. Data were gathered using the Kansas Science Instruction Survey (KSIS). The analysis of the data suggests nine conclusions related to standards-based instruction in Kansas. This paper provides a summary of the results and focuses on the implications of each of the nine conclusions and, where appropriate, provides direction for further research. (KHR)

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IMPLEMENTATION OF THE KANSAS SCIENCE EDUCATION STANDARDS: A PRINCIPAL / TEACHER PERSPECTIVE

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Introduction

The Kansas Science Education Standards (KSES) were adopted in 2001. While acknowledging the importance of science content, the KSES propose that science education should develop student's abilities and understandings related to the processes of science and further their knowledge in the applications of science. This vision includes learning science content in the context of inquiry-based instruction that encourages questioning, developing alternative explanations, challenging each other's ideas, and conducting long term open-ended projects. It is a core theme of the standards (KSBE, 2001, p. 96). Historically there have been several goals for science instruction. DeBoer (1991) identifies teaching science as "a structured body of knowledge to be learned" as the most dominant focus of the classroom for the past 100 years. In contrast and similar to the National Science Education Standards (NSES), the KSES provide a common vision that defines scientific literacy in broader terms. Trowbridge, Bybee, and Powell (2000) point out that the national standards provide a balanced approach in goal emphasis. The congruency of the domains in the KSES, the NSES, and the traditional goals of science instruction identified by Trowbridge, Bybee, and Powell (2000) are outlined in Appendix A.

In spite of the recommendations made in the standards, what if administrators and teachers do not entertain these same expectations for science instruction? What if there are elements in the school system that conflict with this broader perspective on goal emphasis? If

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either of these are the case, to what extent can the practices of teachers be expected to change? Roger Bybee (1997), a respected authority in science education states,

> I came to the conclusion that it is not new materials or national reports that make a difference for most science teachers. Something much deeper and more important is influencing the direction of science teaching. Resistance to change must be related to other factors. One could be that science teachers do not know or do not share the larger purposes of science education stated in so many reports. It could also be that the needs of science teachers are largely met by current practices, or that the school system does not really support any sustained effort to improve science teaching (p. 44).

In sum, if Kansas' reform efforts in science education expect teachers to incorporate and internalize practices consistent with the KSES document, it is vital that considerations go beyond the adoption of a state framework. Clearly, obtaining the perspectives of principals and teachers on science instruction could provide valuable insights into the status of the science reform efforts in this state.

To more fully understand these issues, principal and teacher's ideas about the KSES were examined through the lens of what is known about educational change. Implementation is the aspect of change that corresponds to putting the ideas and programs of an innovation into practice (Fullan, 2001, p. 69). While the KSES are not dogmatic in that they require a specific local curriculum (KSBE, 2001, p. 3), the writers have provided a clear direction for science instruction in the state to move toward. The intent is for Kansas's educators to use them "...to judge whether current actions serve the vision of a scientifically literate society" (KSBE, 2001, p. 3). Like others, Fullan has noted when considering whether an idea or program will be implemented, the characteristics of the innovations themselves are important (Rogers, 1995; Fullan, 2001). In Fullan's (2001) model, four key characteristics effect whether and how an innovation is implemented. These are need, clarity, complexity, and quality.

In regards to the KSES, need relates to the strength of the perceived need by educators to implement the standards. Clarity addresses how well educators understand the changes the standards are trying to accomplish. Complexity comprises the difficulty and amount of change educators will have to go through in order to implement ideas and practices that are consistent with the standards. Quality refers to the quality of the change itself. This goes beyond the presence of adequate time and resources to make changes and includes the motivations behind the adoption. Fullan (2001) cautions against thinking about these factors as if they worked independent of each other. He suggests they interact over time. He explains that the more these factors support implementation, "...the more change in practice will be accomplished (Fullan, 2001, p. 71).

Goal of the Study

Whereas the KSES provide a direction for science instruction in Kansas, little research exists on the implementation of these standards. Literature clearly identifies both principals and teachers as having an impact on the quality of instruction (Darling-Hammond, 1996; Fullan, 2001; NRC, 2001; Rhoton, 2001). It was therefore important to obtain principals' and teachers' ideas about the science standards. Specifically, the study sought to determine the perspectives of Kansas' principals and teachers as they related to the implementation of these standards. Given this purpose, the expectation was that principals and teachers would have differing perspectives.

Methodology

Data were gathered using the Kansas Science Instruction Survey (KSIS). The survey was mailed in January of 2002 to principals and teachers of science at three different grade levels (elementary, middle, high school). To ensure adequate representation from schools of all sizes, participants were selected from small, medium, and large schools.

The KSIS examined three areas: 1) Fullan's (2001) characteristics of need, clarity, complexity, and quality; 2) statements in the Kansas State Board of Education document outlining the standards' changing emphases (KSBE, 2001); and 3) principals' and teachers' goals for science instruction (see Appendix B for the principal version of the KSIS; see Appendix C for the teacher version of the KSIS). The first section used 3 items in each of the four areas to identify factors that might be hindering the implementation of the standards. The second section contained a list of science teaching practices that was based on information found in the KSES document. The standards outline nine examples of how teachers should change their emphasis during science instruction to promote inquiry; because of space limitations on the instrument only five of these were used in the survey. Principals and teachers were asked to respond to these items for two reasons. First, the section was designed to determine whether principals' and teachers' perspectives of quality and teaching were aligned with these recommendations. Second, it was used to ascertain the extent to which principals and teachers thought these practices took place in the classroom. The third section of the KSIS contained two open response items. The purpose of this section was to allow principals and teachers the opportunity to share their own ideas as to what the goal of science instruction should be.

To ensure the instrument's content validity, the instrument was reviewed and revised on several different occasions. The researcher asked a panel of expert judges who had knowledge and experience with the issues involved in the study to compare the content of the questions on the instrument to the goals and questions of the study. The instrument was also reviewed by a focus group of one science educator and seven graduate students in a science education research course. In addition to this, the researcher examined the instrument item by item with four different principals and teachers to ascertain the clarity of the questions and their understanding

of each item. Any item that was troublesome for these individuals was clarified through definition of terms, giving examples, or rewording. Before mailing the instrument, it was field-tested on seven teachers and principals. In each case, items that were identified as unclear, inappropriate, or unrelated to the study were edited and where needed, other items were added /deleted.

Description of the Sample

Questionnaires were mailed to 447 principals, and 775 teachers in Kansas. Participants were stratified according to grade level (elementary, middle, high school) and school size (small, medium, large). A total of 233 (52%) principal's questionnaires were returned and 304 (39%) teacher's questionnaires were returned. Table 1 shows the return frequency and percentage of the questionnaire by each stratification cell.

Table 1

Return Frequency of KSIS by Grade Level and School Size

	Questionnaires Sent/Returned (%)					
	Small Schools		Medium Schools		Large Schools	
	Principal	Teacher	Principal	Teacher	Principal	Teacher
Elementary level	49/26 (53%)	98/41 (42%)	50/25 (50%)	100/34 (34%)	50/25 (50%)	98/26 (27%)
Middle level	49/23 (47%)	61/23 (38%)	50/29 (58%)	87/38 (44%)	50/21 (42%)	96/37 (39%)
High School level	49/28 (57%)	63/28 (44%)	50/25 (50%)	82/34 (41%)	50/25 (50%)	90/42 (47%)
Total Number of Principal Questionnaires 447/233 (52%)			Total Number of Teacher Questionnaires 775/304 (39%)			

Note: Seven additional questionnaires that were included in the total count had school sizes that could not be identified and therefore were not included in the individual cell counts.

This sample yielded the minimum of 20 persons per subgroup suggested by Fink & Kosecoff (1985) so that meaningful statistical comparisons could be made. The Beale Code was used as a demographic to determine the alignment of the sample to the population. The Beale Code is a rural-urban coding system that classifies counties into one of nine categories (Beale and Butler, 1993). The results of this analysis indicated that the sample of principals aligned demographically well with the population. While not conclusive, the analysis indicated the sample might contain 10%-18% more science teachers from districts not adjacent to metro areas. While this was important to note, the differences in orientations between metro and non-metro teachers was left open as an area for future investigation. It was concluded that obtaining an adequate number of teachers in each cell of the sample was sufficient. The assumption being that

the sample adequately represents the variety of perspectives held by teachers who teach science in Kansas.

Analysis of the Data

Descriptive data from the principals and teachers responses were gathered and analyzed. In addition, a chi-square analysis was used to test for statistical significance of observed differences between principals' and teachers' perspectives at each grade level (elementary, middle, and high school). Each of the 22 items on the KSIS was tested three times. The level of significance was established at alpha = .01. This reduced the probability of Type I error accumulation due to multiple chi-square tests.

Analysis of the two open-ended items was accomplished by compiling the responses of principals and teachers. Berg (1998) describes the process of condensing and coding the data to make systematic comparisons as content analysis. Data were first reviewed several times to identify key words and concepts. A second observer verified the coding of these items. Items that caused disagreement were discussed and negotiated until agreement occurred. Similar key words and concepts were then grouped together to determine frequency of occurrence. Groups of words and concepts were then checked for their fit into the three traditional goals of science instruction. These include teaching science for knowledge, teaching science to develop the processes of science, and teaching science as it relates to personal needs and societal issues. All three are represented in the standards (Trowbridge, Bybee, & Powell, 2000). Groups of key words and concepts not fitting into one of the three goals, but still having significance, were noted and reported separately.

Conclusions and Discussion

The analyses of data led the researchers to make nine conclusions related to standards-based instruction in Kansas. The discussion that follows provides a summary of the results and then focuses on the implications of each of the nine conclusions and where appropriate, provides direction for further research.

1. As a whole, perspectives of teachers and principals are not substantially different.

Contrary to the researchers' initial expectations, there was much continuity between principals' and teachers' perspectives. Chi-square tests only yielded differences on two items. On the first item of difference, principals at all three grade level were much more uncertain than teachers about modifying texts activities and other curricular resources to align with the standards. The second item of difference related to planning time. While almost half of all educators at each level indicated there was a lack of adequate planning for science, teachers at the elementary and middle level were more likely to indicate this as a problem than their principals. Because of the nature of their jobs, principal / teacher differences on these items were not surprising.

While the apparent coherence on the rest of the items was not expected, it does suggest that professional development might be easier. Staff developers will be working with a set of beliefs that are somewhat homogeneous. It is possible that by setting the level of significance at .01, some differences were not detected. However, conducting a multiple numbers of tests warranted a more conservative approach.

2. Principals and teachers believe that science instruction should be aligned with the standards.

Over 90% of the educators in this study indicated that science instruction should align with the standards. This represents a strong foundation for change. However, Rogers (1995)

explains that it is important to assess the needs of those adopting an innovation accurately. For example, teachers and principals mentioned the value of standards in establishing a coherent K-12 science program and thus, it addressed an area of concern. One middle level teacher explained, "…I agree with most of the state standards and try to teach them. I think it is important to have the Jr. High/High School curriculum aligned." On the other hand, both teachers and principals mentioned the state assessment as the driving force behind their need. For example, a middle level principal stated his goal for science instruction was to "Increase scores on the Kansas state science assessment and the criterion reference tests which are aligned with the state objectives." Each scenario carries different implications for standards-based reform in Kansas.

At one extreme, principals and teachers can interpret standards-based science instruction as preparation for the state assessment. Thus, science instruction becomes a series of test preparation exercises, limited only to the content of the test. Teachers in this scenario become technicians whose responsibility is to ensure students do well on the exam. A contrasting perspective visualizes the standards as the collective wisdom that practice and research have synthesized into a common vision. In this vision, the standards become a guide on which professionals base their judgments and decisions. While relevant, test scores are only one of several data sources on which decisions are made.

This suggests that further research should be conducted to ascertain the source of the perceived need and provides an important area for conversation. Those with a vested interest in science reform need to have an understanding of what the standards document and the state assessment are. While related, they are not the same. This points to another area of much needed research. More study must be done to determine if the state assessment aligns with the

constructivist goals set forth in standards. At the very least educators need to explore the limits of the assessment to better understand the role it can play in improving science instruction their buildings.

3. Improvement of science instruction does not have priority compared to other areas.

Compared to other content areas, improvement of science does not have priority. Fullan (2001) reports that schools are faced with innovation overload. There are limits to the number of improvement programs in which a school can be involved. This implies that more pressing needs may overshadow the need for science instruction to be aligned with the standards. The large numbers of educators in the state who indicate that improvement in science is not as high a priority as other subject areas leave doubts about how quickly change in science instruction will occur.

The most critical area of concern is at the elementary level where almost 80% of the elementary teachers and 60% of the elementary principals indicated other content areas have priority. Qualitative responses provided further insights. Both principals and teachers see mathematics and reading as top priorities at this level. One elementary principal stated, "Science instruction in the primary grades is less important than establishing effective readers. With the new mandate to test elementary in reading and math, the time for science may be even further eroded." A 4th grade teacher explained, "I don't believe science should be emphasized in a K-4th grade building. More time should be spent in reading and math."

While these comments provide insights at the elementary level, they do not explain the 40%-50% of the teachers at the other two grade levels that also indicated a similar lack of emphasis. Why this percentage of middle and high science teachers indicated improvement in science was not as high a priority as other areas is certainly an area for further exploration. One

possibility to explore is the influence Quality Performance Accreditation has in this. It is the system the state uses to evaluate Kansas' schools.

4. The instructional practices currently emphasized in a large number of classrooms ensure students have a limited exposure to the full meaning of science as expressed in the standards document.

The study data suggests large numbers of students have limited exposure to the full meaning of science as expressed in the standards document. The study revealed that connections to content areas such as historical perspectives, technological applications, and relevant topics were rarely mentioned in respondents' comments. This suggests most educators still think about science in terms of the traditional content areas of life, earth and physical science. In addition, a large number of high school teachers (51%), middle level teachers (36.1%), and elementary teachers (17.6%) reported that conducting investigations over extended periods of time was not emphasized. This is far short of the goal the science standards have set for science instruction in Kansas.

The study data suggest many Kansas students, especially in the upper grades, are experiencing science as a series of one day exercises, with few opportunities to explore anything in depth-which is the core of any scientific endeavor. Consider the types of experiences students miss by having limited opportunities to be involved in investigations that extend over a period time. Experiences such as group investigations and science fairs (Howe and Jones, 1998), internet and science projects (Chiappetta and Koballa, 2002), and problem-based learning (Martin, et al. 2001) are the types of activities that most likely are not occurring in these science classrooms. Since teaching science as way of knowing is at the heart of standards-based practice, this greatly reduces the quality of science inquiries. These findings are even more disturbing for

middle and high school students, where a large number of middle level teachers (36.9%) and high school teachers (41.3%) reported not focusing on a few fundamental topics. This practice ensures that students receive a surface knowledge of the science content and do not experience authentic inquiry.

Topic areas such as personal and social perspectives relate science instruction to students' everyday lives, thereby providing them with information about real world issues and challenges. The lack of reference to this area was especially weak at the elementary level. Only three responses were identified as fitting into this category. For example, a 4th grade teacher's comment said, "Students will learn facts regarding rocks, plants, ecology and simple machines." In this case, ecology was interpreted as relating to things like natural resources, the environment, recycling or pollution. In addition, only 8.7% of the elementary teachers mentioned relevancy as a goal for science instruction. The standards define this at the elementary level as students having health and environmental issues integrated with the other content areas. If the elementary grades are neglecting this standard as these data suggest, then students may be missing important experiences that deal specifically with their health and well being. One important issue, weather safety, is especially relevant given the frequency of thunderstorms and tornadoes in Kansas.

This information also is important because it provides specific direction for those seeking to improve science instruction. Those with professional development responsibilities should ensure that teachers have adequate skills and knowledge to utilize these strategies through providing quality professional development opportunities with standards-based practices. In addition, teachers need to be made aware of curriculum and resources that allow them to effectively integrate historical and technological aspects into their classroom. As schools adopt curricular resources, those in charge of these decisions should seek standards-based resources

that synthesize the key science topics and facilitate long-term investigations. Perhaps the biggest key is for teachers and principals to have meaningful conversations about where these practices fit into the curriculum.

The broader impact of reform efforts regarding standards-based practices should not end at the 12th grade. They should also impact how science is taught at the college and university levels in both content courses and teacher preparation programs. For example, students who experience long-term investigations better understand the conceptual and process skills involved in "doing" science and may be better prepared to teach in a similar manner. Also, exposure to historical and technological aspects of science will provide students with the competence to address these areas. This suggests that course work at the university level should allow teacher candidates opportunities to experience science in a way that is consistent with the standards as well.

The reasons the principals and teachers reported these practices as not emphasized are not clear, but several possibilities exist. For instance, teachers may not believe the particular practices are important or perhaps they lack skill to carry out these practices. Another reason may be the recognition that both require a commitment of time. For example, secondary science teachers who are constrained by 50-minute class periods may feel that long-term studies are not efficient use of time. Qualitative data suggest many high school teachers feel obligated to prepare their students for college level course work. For example, one high school teacher said, "...I don't approve of the state assessment or the science standards because they don't appear to prepare the students for the next level of instruction." Last, William Schmidt, director of the Third International Mathematics and Science Survey (TIMSS), reports that textbooks affect which topics teacher select and how much time they devote to them (Engleman, 2002). Any or

all of these could be factors that influenced the perspectives of the respondents regarding this issue. Clearly this is an area for future research. A series of in-depth interviews at each grade level could identify specific constraints that hinder teachers from emphasizing these practices and provide venues to help teachers move beyond the constraints.

On a more general basis, self-reported data is limited. Surveying teachers and principals was a good first step, but to understand what is happening in the classroom, on-site observations need to be conducted with protocols that can determine the extent standards-based teaching practices are occurring in the classroom. Complementing these observations and self-reported data, instruments such as the Constructivist Learning Environment Scale (CLES) developed by Taylor and Fraser (1991) could provide student data to assess the degree a particular classroom's environment is consistent with constructivist assumptions of teaching and learning (Fraser, 1994). Even more recently, the Reformed Teaching Observation Protocol (RTOP) instrument holds promise for measuring reform practices in science and mathematics classrooms K-16 (Piburn, M., Sawada, D., 2000).

5. Principals and teachers place importance on practices that are not consistent with standards-based science instruction.

This study revealed there are large numbers of principals and teachers with views on science instruction that differ from those outlined in the standards. Specifically, 20 - 30% of all respondents favored covering many science topics over placing more emphasis on studying a few fundamental concepts. A slightly lower percent of all respondents (16-26%) favored conducting investigations that are confined to one class period rather than extending them over a period of time. In similar fashion, 15-29% of all respondents indicated science instruction should emphasize process skills separately out of the context of inquiry rather than using them in

context. The numbers at all grade levels indicating disagreement with these practices are curious considering the large numbers (90% +) that indicated the need for teaching strategies to align with the standards. This reinforces the necessity for further investigation into the sources of respondents' perceived need to align with the standards.

Several sources of data indicated that high school teachers value covering content at the expense of process more than any other sub-groups. For example, 30% of the high school teachers did not agree that more emphasis should be placed on studying a few fundamental concepts rather than covering many science topics. As mentioned previously, qualitative data suggested one of the reasons high school teachers value covering content is the obligation they feel to prepare students for college. If a large segment of teachers remain unconvinced about the appropriateness of inquiry-based science instruction in meeting the immediate needs of their students, why would they adopt these strategies? To gain widespread acceptance at the classroom level, high school teachers must understand and value this type of learning. As long as these high school teachers believe they are best meeting the needs of their students by focusing on content, one has to question whether their practice will change.

If we assume all educators want teachers to teach well and all want students to achieve, it then becomes apparent that many practitioners may not believe that the practices advocated for emphasis are the most suited in accomplishing what they value as educational goals. This underscores the value in helping principals and teachers to understand how and why a standards-based curriculum is important to their students, specifically how this prepares students for the next level. This applies to all grade levels. If educators do not share the same values as the standards, it is questionable whether teachers will ever fully embrace the vision of science instruction outlined in the standards. Change will be more difficult for these individuals because

it will require them to alter their beliefs (Fullan, 2001). A critical question science reformers need to consider is how to get more educators to value standards-based practices.

Richardson (1996) identifies changing beliefs and practices as the greatest controversy in teacher change literature. She reports that some think beliefs are too difficult to change and others advocate that "...teachers can and do change and programs can help them" (p. 110). Ultimately, however, if educators value something other than the standards, there is little that can be done. Fullan (2001) explains that dealing with beliefs and behavior when attempting to change is complicated, but he emphasizes the need to address them "...on a continual bases through communities of practice" (p.45). He suggests that beliefs are most effectively discussed after teachers have experiences trying the new practice. Loucks-Horsley et al. (1998) states that practicing new behavior can result in new attitudes and beliefs. Conducting investigations over extended periods of time, focusing on fewer topics, and using process skills in the context of inquiry represent specific areas where discussions between principals and teachers should occur. Professional development plans and teacher in-service could be based upon these science standards-based practices as well.

All of these issues point to the need for further research. Are the science standards making a difference in the quality of science instruction? Certainly the standards are consistent with research on teaching and learning (NRC, 2000). But does the type of learning suggested in the standards reflect equally well on the indicators educators frequently utilize to determine quality instruction. In Kansas, the state science assessment would be a primary indicator, but other indicators could also include ACT scores, AP science exams, and PSAT scores. Data on this link is essential if educators are to invest in large-scale change.

6. Teachers at all grade levels are experiencing external constraints that are influencing their practice.

Tobin, Tippins and Gallard (1994) reported the work of Benson (1989) in explaining that teacher beliefs may not directly relate to teacher actions. They reported gaps between what science teachers said they believe and what they practice. When questioned about these apparent contradictions, teachers cited the presence of external constraints, rather than their beliefs, as a major factor influencing their practice. In other words, there are some practices that teachers might value, but don't implement them because of constraints.

To gain insights into whether this was occurring in this study, an exploratory analysis was conducted on data from the teaching practices section of the instrument. Recall, part of this section asked respondents to indicate the extent they thought certain practices like conducting investigations over an extended period of time and using process skills in the context of inquiry should be emphasized. The other part of this section asked teachers to indicate the extent these practices actually occurred in their classroom. Discrepancies in the data between these to sections were interpreted as constraints.

The analysis revealed that differences between these sections did exist. The largest difference (34.7%) occurred at the high school level. While 83.7% of the high school teachers indicated teachers should emphasize science investigation that extend over a period of time; only 49% indicated this was emphasized in the classroom. Although smaller, each grade level contained at least two items with over a 10% difference. This suggests there are elements present in the system, other than teachers' beliefs, that are deterring teachers from implementing the practices advocated in the standards. These constraints could be magnified for those teaching in non-certified areas where there is greater need for support and professional

development. It follows that to increase the number of teachers that implement these practices; an important next step is to identify the constraints, both internal and external, prohibiting the use of these practices. In this way, principals and teachers can work together to address them.

One likely source of pressure at the high school level that was already discussed is the perceived need to prepare students for college where the traditional emphasis on content is perpetuated within the system. Efforts such as the Kansas Collaboration for Excellence in Teaching Preparation (KCEPT) and the PDS Partnership at Kansas State University are attempting to change the focus of these systems so the content courses more closely reflect the reformed based practices outlined in the National Science Education Standards. However, it is unlikely changes in these systems will occur very rapidly. Until then, it is unlikely this pressure at the high school level will go away.

Another possible area identified in this study relates to a lack of planning time. Both principals and teachers identified lack of planning time as an issue for teachers at all levels. It appears the elementary grades have the most difficulty with this issue. Only 15.7% of the elementary teachers and 33.4% of the elementary principals indicated teachers had adequate planning time. While other researchers have identified possible constraints such as lack of supplies, insufficient lab space, lack of planning time (Teters and Gabel, 1994), the quality of textbooks (Schmidt, et al. 1997), outdated facilities and equipment (Lewis, et al. 2000), there is a need to identify constraints in local contexts so that parents, administrators, school boards and teachers can work together to resolve them.

7. Principals and teachers lack understanding of the instructional practices advocated in the standards.

Fullan (2001) identified clarity as an essential element if implementation of an innovation like the standards is to occur. He discusses that lack of clarity is expected and may not be bad as long as those needing it get support. Without this, trying to adopt changes will only lead to frustration. He also mentions that it is common for people to oversimplify a change and not realize all it entails. In essence, they think they understand or are making changes, but in reality are not. One of the limitations of self-reported data is its inability to detect whether respondents have a false sense of clarity. However, these data were able to identify large numbers of all respondents admitting to having doubts about their understanding of the learning theory upon which the science standards are based (19-29%), difficulty recognizing whether science-teaching practices are consistent with the recommendation of the science standards (30-46%), and difficulty with the modification of text activities and science materials so they more closely align with the standards (22-58%). This suggests it is important that these individuals get the support they need to make the changes advocated in the science standards.

In addition, use of the word "experiment" by some respondents suggested multiple meanings that ranged from designing a fair test to being used synonymously with doing any activity. For example, one primary teacher wrote, "I try to do as many hands-on experiments as possible to illustrate concepts." From this context, it is likely that the term experiment refers to an activity; not the more precise definition utilized in the standards. This emphasizes the importance of ensuring principals and teachers understand the meaning of standards-based terminology.

The use of precise terminology becomes a bigger issue when considering what "doing" science actually looks like. The standards refer to this as inquiry. An analysis of responses for goals that related being actively engaged in scientific processes, investigations, inquiry, etc… yielded a large number of respondents that mentioned this as a goal (38-57%). Unfortunately, responses of teachers and principals at all levels seemed to indicate some hold a simplistic notion of a scientific method that involves specific steps. A middle school principal explained, students should "know the steps of the scientific method." A high school principal stated, "Use the scientific steps in reaching a conclusion…." This idea was not limited to principals. A middle school teacher explained, "A research paper sets up perfect for the students to follow step by step the scientific method."

One possible source for this simplistic notion of science was evident in the data. One is the way science tends to be portrayed in textbooks. A 5th grade teacher shared, "Our McGraw Hill text "Explore Activity" works well to teach the scientific method." Although this statement does not reveal the respondent's conception of the scientific method, it does reveal the source for her activities. If teachers rely heavily on texts to supply structure and content for their courses, it follows that the quality of science instruction will be directly influenced by the quality of the textbooks.

It is also important to note that almost 20% of the principals and teachers at each grade level indicated they did not understand the learning theory guiding the standards document. This suggests that even if practices consistent with the standards are adopted, at least 20% will not be doing so because they do not believe and understand them. Fullan (2001) explains that it is possible for practitioners to use materials and imitate behaviors without actually understanding

the rationale behind making the change. Lasting change depends on teachers embracing more than a surface adoption of materials and methods (Fullan, 2001).

This large number of respondents indicating a lack of clarity raises important questions. What criteria do these educators utilize to make instructional decisions? What criteria do they use to make judgments regarding quality science instruction? This illustrates why too often the adopted textbook or other adopted materials become the curriculum. It also suggests why the state assessment, not the standards, is influencing the planning and evaluation of science instruction for many educators.

To lessen this lack of clarity, there are several options. Loucks-Horsley et al. (1998) discuss the need to develop local leadership to assist in modeling and coaching. In addition, professional developers should consider making resources such as NSTA's Pathways to the Science Standards and the National Research Councils' Inquiry and the National Standards available to teachers and principals. To address curricular material concerns, Huber and Moore (2001) provided a model for making traditional hands-on activities inquiry-based. These are the kinds of practices and materials that need to be available to inform the focus of discourse among practitioners seeking to make changes.

The large numbers of respondents indicating lack of clarity in the areas of curricular resources and instructional practices, point to two areas of further research. First, it would be important to determine the curriculum adoption strategies utilized in schools and districts. Second and equally important, it would be to determine how principals assess science teachers' instructional practices.

9. Principals and teachers are satisfied with the learning environments available for teachers to develop deep understanding of the standards.

While it is not certain how respondents defined quality professional development, almost half indicated access to it was a problem. Yager and Pennick (1990) reported a persistent gap between pre-service and in-service science teacher education. They identified the failure of NSF from 1960 - 1975 in its attempts to narrow this gap by supporting in-service that focused on updating science preparation. From their perspective, the key element that contributed to this failure was the use of the sponge model. "If a teacher can soak up enough current information, most problems disappear, because teachers merely communicate information to students and insist that they commit it to memory" (Yager and Pennick, 1990, p. 665). They assert that the problem with the sponge model is that it never developed the teachers' ability to evaluate the instruction they provided.

In contrast, Loucks-Horsley et al. (1998) report that the beliefs about professional development have changed in the last 25 years. She states the concept of professional development has widened to include both the teacher and the organization in which the teacher belongs. Unlike the sponge model, "[e]ffective professional development experiences are continuously assessing themselves to ensure positive impact on teacher effectiveness, student learning, leadership, and the school community" (p. 37).

In spite of the high numbers indicating difficulty accessing professional development, over 70% of the all teachers and over 80% of all principals reported that school environments encouraged teachers to develop a deep understanding of the standards. When combined with the data that indicates almost half of all the principals and teachers believe there is a lack of adequate planning time, these percentages are perplexing. It would seem access to professional

development and having planning time to discuss the science curriculum should be more closely related to developing a deep understanding of the standards. This raises the question, what do principals and teachers consider deep understanding? This is an area requiring further inquiry.

A CLOSING THOUGHT

> Well, the hard work is done. We have a policy passed; now all you have to do is implement it.
>
> (Fullan, 2001, p. 69)

As the conclusions of this study indicate, the issues surrounding standards-based science reform will not be resolved by the efforts of one part of the system. Like the links in a food web, all parts of the educational system are intricately connected and have influence on each other. In spite of the simplicity suggested in the quote above, moving the vision of the science standards forward is a process that will move ahead only as those individuals in local contexts begin to make changes. While far from inclusive, this study has provided those who want to make changes with specific areas where they must begin to work.

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Appendix A

The Congruency of Traditional Science Instruction Goals with National and Kansas Science Education Standards.

Goal of Science Instruction*	National Science Education Standards**	Kansas Science Education Standards***
Development of Scientific Knowledge	Physics and Chemistry, Life Science, Earth and Space Science, Science and Technology, History and Nature of Science and Unifying Concepts and Processes	Physics and Chemistry, Life Science, Earth and Space Science, Science and Technology, History and Nature of Science and Unifying Concepts and Processes
Development of Scientific Methods	Science as Inquiry, Science and Technology	Science as Inquiry, Science and Technology
Relating Science Instruction to Personal Needs and Societal Issues	Science in Personal and Social Perspective	Science in Personal and Environmental Perspective

* Trowbridge, Bybee and Powel (2000) identified these as historical goals for science instruction and aligned them with the NSES as presented in this table. It should be noted that career awareness was also identified as a goal. For a complete discussion in this topic see the text.

** A copy of the National Science Education Standards can be accessed online at http://www.nap.edu/readingroom/books/nses/

*** A copy of the Kansas Science Education Standards can be accessed online at http://www.ksbe.state.ks.us/outcomes/science.html

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